PATENT SPECIFICATION

DRAWINGS ATTACHED

922,982

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International Classification:—G08c.

COMPLETE SPECIFICATION

Load Cell

We, CARL SCHENCK MASCHINENFABRIK G.M.B.H., of 55, Landwehrstrasse, Darmstadt, Germany, a body corporate organised under the Laws of Germany, do hereby declare the
5 invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —
10 This invention relates to a load cell or pressure gauge comprising a circular plate to which the force is centrally applied, whereas the plate is supported peripherally.

For measuring a force use is generally made
15 of the fact that a body of known mechanical properties is deformed when acted upon by a force. In known load cells, this deformation is determined by measuring the degree of deflection or the resultant compressional or
20 tensile strain. In electrical load cells which are preferred because of a variety of advantages which they possess strain gauges are generally used which function in that changes occur in their inductance, capacitance, ohmic
25 resistance and so forth when under strain.

In load cells in which deflections are measured it is already known to apply the force to an elastically flexible plate which is peripherally supported and to measure the
30 deflection of the plate under load.

In known load cells based upon the measurement of strain a cylindrical element which carries strain gauges affixed axially and transversely thereto is subjected to the action of
35 the measured force, or a ring-shaped member is arranged to carry radially disposed strain gauges around its periphery and the measured force acts normally to the line connecting the strain gauges.
40 Whereas the accuracy which can be achieved with load cells based on the measurement of a deflection is limited it is a drawback of load cells which measure the strain that their structural height is fairly considerable and
45 that they must be very precisely constructed and adjusted. In load cells comprising cylindrical deformable bodies the axial application of the load produces a negative strain in the axial direction amounting to say ϵ, accompanied by a positive strain in the
50 transverse direction of about 0.3 ϵ. If four strain gauges are used and combined for instance in a Wheatstone bridge, two being axially disposed and two crosswise thereto, then the total difference in the bridge will
55 accordingly be about 2.6 ϵ. In load cells comprising an annular deformable element the strain gauges are subjected to flexural as well as to tensile and compressional strain. If two strain gauges are affixed to the outside
60 and two to the inside of the ring, the outside strain gauges when measuring a drawbar pull will be negatively strained, whereas those on the inside will be positively strained. Owing to the annular shape of the deform-
65 able element the distribution of the strain along the strain gauges varies. In all four strain gauges the flexural strain is accompanied by a purely tensile strain which in order of magnitude is about 5 to 20% of the
70 flexural strain. In the case of four strain gauges the total strain is therefore, as a matter of experience, about 3 to 3.5 ϵ.

The problem contemplated by the invention is that of providing a load cell which is
75 simple to manufacture and handle, which has a relatively low structural height and which gives results of satisfactory accuracy. According to the present invention there is provided a load cell comprising a circular plate to
80 which the load to be measured may be centrally applied and which is peripherally rigidly supported, and wherein the thickness of the plate is a function of the radial distance from the centre of the plate and so
85 calculated that in magnitude the radial strain under load is approximately constant along the entire plate radius but changes in sign at a point located at a given distance from the plate centre.
90 In order to enable the invention to be more readily understood, reference will now be

made to the accompanying drawings, which illustrate diagrammatically and by way of example some embodiments thereof, and in which: —

Fig. 1 is a longitudinal section through a load cell with strain gauges for measuring thrust,

Fig. 2 is a graph illustrating the distribution of strain along the radius of a deformable member of the load cell shown in Fig 1,

Figs. 3 and 4 are longitudinal sections of alternative components of the load cell for performing different kinds of measurements,

Fig. 5 is a longitudinal section of a modification of the load cell shown in Fig. 1, comprising a deflection-measuring element.

The load cell illustrated in Fig. 1 comprises a circular plate 1, formed at its periphery with a rigid annular portion 2. The plate 1 will therefore behave as if it were rigidly held at the edges. At its centre the plate is formed with a hub 3 to which the load P which is to be measured can be applied. The space 4 defined by plate 1 and ring 2 is closed by a cover 5. Fixing screws 6 for the cover 5 have crowned heads and are so disposed that they can simultaneously serve for supporting the gauge on a surface, three screws 6 being provided at angular intervals of 120°.

The thickness of the plate in the radial direction varies. The variation in thickness is calculated to produce a strain curve a which, related to the radial distance from the plate centre, has a rectangular shape as illustrated in Fig. 2 in respect of one half of the plate. Proceeding radially outwards from hub 3, and assuming that the load P is applied in the direction indicated in Fig. 1, the underside of the plate is first subjected to a positive strain of constant magnitude. At the point where the thickness of the plate is a minimum the strain discontinuously reverses its sign to become a negative strain of the same absolute magnitude. For the sake of comparison the distribution of strain in a plate of uniform thickness is illustrated by curve b.

Unlike a plate of constant thickness, as hitherto used in known load cells which measure deflections, the present load cell provides surfaces of constant strain of sufficient magnitude to be measured by a strain gauge. In Fig. 1 the strain gauges are indicated by reference numerals 7, 8, 9 and 10. Under a load P they are subjected along the whole of their length to a strain which is numerically constant, said strain being negative in the case of the gauges 7 and 10 and positive in the case of the gauges 8 and 9. If these strain gauges are now connected together in conventional manner in a Wheatstone Bridge, then the imbalance of the bridge due to load P for a given strain ϵ between ring 2 and hub 3 corresponds with the maximum possible strain

4 ϵ. This means that the present load cell has the maximum possible sensitivity.

The provision of the cover 5 for enclosing the space 4 merely serves to protect the strain gauges. Changes in atmospheric pressure may easily give rise to a pressure differential between the interior of space 4 and the ambient atmosphere and such a differential may strain the plate 1 in the same way as a load at P, thus falsifying the measurement. In order to overcome this difficulty the cover 5 is provided with a diaphragm 11 which separates a chamber 12 from the interior, said chamber communicating through an opening 13 with the ambient atmosphere. Any pressure differential between the interior space 4 and the chamber 12 causes the diaphragm to be deflected until the two pressures are again equal. Naturally, the diaphragm might be replaced by other suitable means, such as a bellows.

If pressure compensation of this kind is not required for performing certain kinds of measurement, a simple cover as illustrated in Fig. 3 and marked 5a will be sufficient. Moreover, this cover, or a cover of some other shape, may be provided with an abutment for limiting the total deflection of the plate 1, and the cover 5a is provided with such an abutment at 5b.

In order to permit the present load cell to be used for measuring a tractive force suitable elements for the application of such a force are provided. Fig. 4 illustrates a cover 5c of modified construction, which serves such a purpose. This cover 5c has a boss 5d for the application thereto of a tractive force P. If this latter cover is used in the embodiment according to Fig. 1 the direction of the force P indicated in the drawing must naturally be reversed.

When necessary, the present load cell may also be fitted with deflection measuring elements. An embodiment of such a kind is illustrated in Fig. 5. In this arrangement which is otherwise identical with the previously described embodiment the cover 5 carries an element 14 of variable electrical inductance, fitted with a feeler 15 for detecting the degree of deflection of the plate 1. It will be readily understood that alternatively, deflection measuring elements based upon some other functional principle could be employed.

The effect of an eccentric application of a load upon the measured result is very small in a load cell of the proposed kind, because the radial symmetry of the arrangement ensures that any increased strain of one of the gauges is compensated by a correspondingly reduced strain of that strain gauge which is located symmetrically thereto on the opposite side of the hub 3.

The influence of transverse forces Q is also slight because the low height of the hub 3 pro-

vides only a small lever arm which in view of the relatively large transverse section of the plate generates a relatively low strain in the plane of the plate, whereas an axial load P generates a much larger flexural strain.

The upper side of the plate is substantially smooth and, in the unloaded state level. The thickness of the plate, however, varies as a function of the distance between the centre of the plate and its edge in the following manner:—the plate is thickest at its centre and the thickness of the plate decreases in proportion to the radial distance from the centre of the plate until the thinnest point is reached at a radial distance corresponding to approximately half the radius of the plate. From this point the thickness of the plate increases again in proportion to the radial distance from the centre of the plate to the edge of the plate. The plate thus has a cross-section as indicated in Figs. 1, 2 and 5. This design of the plate causes the force acting thereon to produce deflection as a function of the radial distance from the plate centre according to the curve a in Fig. 2. The rates at which the thickness decreases and increases, and the exact position of the thinnest point may depend upon several factors, including the material of which the plate is made and the order of magnitude of the load to be measured, but are readily ascertainable by those skilled in the art.

WHAT WE CLAIM IS:—

1. A load cell comprising a circular plate to which the load to be measured may be centrally applied and which is peripherally rigidly supported, and wherein the thickness of the plate is a function of the radial distance from the centre of the plate and so calculated that in magnitude the radial strain under load is approximately constant along the entire plate radius but changes in sign at a point located at a given distance from the plate centre.

2. A load cell as claimed in Claim 1, wherein the peripheral portion of the plate is itself extended to form a rigid part peripherally supporting the plate.

3. A load cell as claimed in Claim 1 or 2, wherein the plate is provided, in zones of constant strain, with strain gauges, which are connected together in a measuring circuit of conventional kind.

4. A load cell as claimed in Claim 1 or 2, wherein deflection measuring elements are provided for measuring deflections of the plate when subjected to a load.

5. A load cell as claimed in any preceding Claim, wherein the space defined by the plate and by its rigid peripheral support is closed by a cover.

6. A load cell as claimed in Claim 5, wherein the cover is provided with an abutment for limiting the deflection of the plate under a load.

7. A load cell as claimed in Claim 5, wherein the cover is formed with a chamber which communicates with the ambient atmosphere through an opening but which is separated from the interior by a diaphragm.
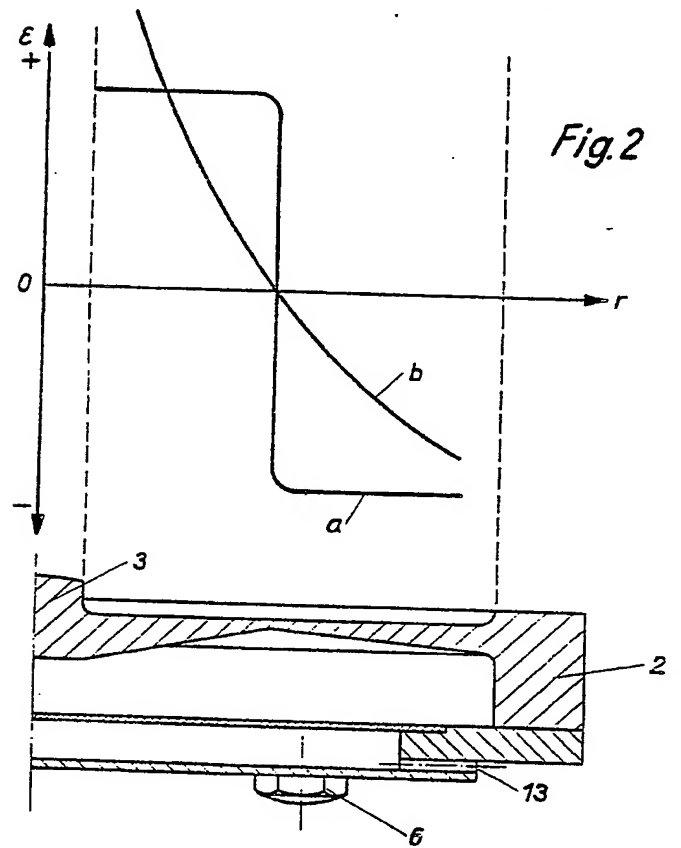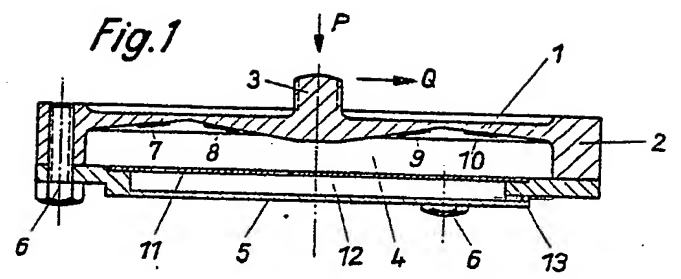
8. A load cell as claimed in Claim 5 or 7, wherein the cover is formed with a boss for the application thereto of a tractive load.

9. A load cell as claimed in any one of Claims 5 to 7, wherein fixing screws for the cover are arranged to support the load cell on a surface.

10. A load cell as claimed in claim 9, wherein the fixing screws have crowned heads and are disposed at angular intervals of 120°.

11. A load cell substantially as hereinbefore described with reference to Fig. 1, 2 or 5 or Fig. 1 as modified by either of Figs. 3 and 4 of the accompanying drawings.

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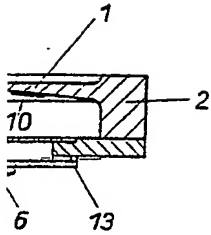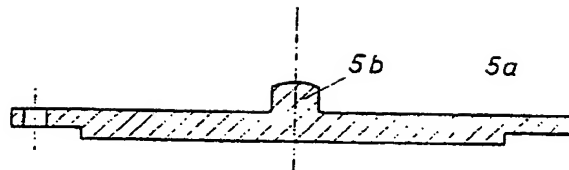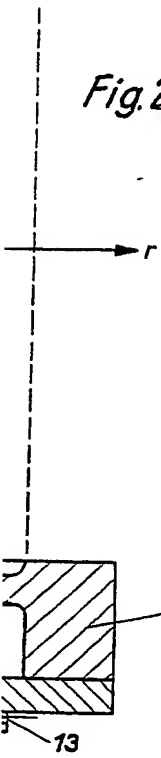London, E.C.1.
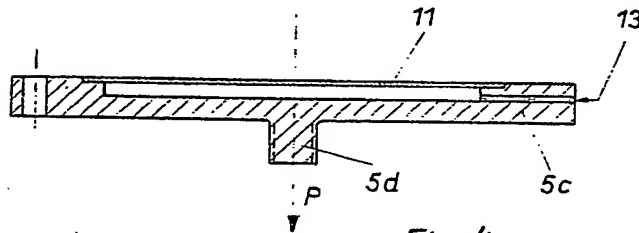Agents for the Applicants.

Fig.1

Fig.2

1

2

10

6   13

Fig.2

2

13

r

5b   5a

Fig.3

11   13

5d   5c

P

Fig.4

P

3   1

15   2

6   5   14   6   13

Fig.5

Fig.3

Fig.4

Fig.5

Fig.1

Fig.2